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of the subject would include an account of the beautiful polished celts of jade found in the tumuli, of the gold and bronze ornaments, of the pottery, the decoration, the art, of the tools and implements of this early people which cannot be presented within the limits to which this paper must be restricted. I omit, for the present, the cromlechs, the places of incineration, the Roman remains, and many other subjects of equal interest. Perhaps at some future time I may refer to them.

DR. N. O. HOLST'S STUDIES IN GLACIAL GEOLOGY.

BY DR. JOSHUA LINDAHL.

WE have before us two pamphlets by the Swedish geologist, Dr. Holst, of Stockholm. One of them bears the title, "Om de glaciala rullstensäsarne" ("On the Glacial Gravel-Osar"[1]); the other, "Berättelse om en i geologiskt syfte företagen resa till Grönland" ("Report on a Voyage to Greenland for Geological Investigations"[2]). The subject of these papers has so much bearing on the geology of our own country, and is so ably treated by their author, that we have thought it desirable to present the following condensed translation of them.

In the first-mentioned paper Dr. Holst propounds his new theory of the origin of glacial osar.

The history of the development of this theory is, briefly, the following: Hisinger (in some cases), Martins, Chambers, A. Erdman, Torell, and others, explained the said formation as ancient seashores. Hisinger (in other cases), v. Helmersen, Törnebohm, Levin, Jernström, and others, assumed that a vast deposit of sand and mud covering the country had been cut through by rivers, whose beds were gradually filled with stones and gravel. Later

[1] Geologiska Föreningens i Stockholm Förhandlingar, 1876. No. 31 (Band III., No. 3), pages 97-112.

[2] Sveriges Geologiska Undersökning. Afhandlingar och uppsatser. Ser. C, No. 81. Stockholm, 1886. Pages 1-68.

the sand and mud was washed away, leaving the stone and gravel deposits of the rivers in the shape of ridges. Hummel was the first one to recognize the fact that the existence of an inland ice must be pre-supposed as the indispensable agent in forming such ridges; but he regarded them as formed beneath the ice in tunnels excavated by percolating waters. Finally, in 1876, Holst published his new theory, which in 1878 was also used by Warren Upham in his report of the geology of New Hampshire.[1] Dr. Holst's theory stands now without a rival.

The following short extract of Dr. Holst's paper may be sufficient to explain his views. He says :—

"For a correct interpretation of the origin of gravel-*osar* it is of main importance to answer the question how it was possible for running water to deposit its silt in such shape as that of an ordinary gravel-ose.[2] There can be no further dispute that these deposits are old river-beds. How, then, have they happened to assume the form of elevated ridges, rising above the adjacent country? "

The water at the surface of the melting glacier gathers in the valleys of the ice-sheet, whence it extends its coastward course in rivers whose beds are cut down in the ice-sheet. The ice along these rivers melts faster than that farther off, and in melting it gradually releases its contents of moraine matter. This matter will then follow the water, although at a far slower rate, down to the said valleys, and is finally—at least partially—swept along into the rivers, where the gravel-grains will be worn and their angles will be more or less rounded off, according to the swiftness of the current. This same factor will also regulate the assorting of the material and determine the place where each individual boulder, pebble, or grain shall be dropped. Layer upon layer will thus accumulate in the river-bed, and, when finally the entire glacier has melted away, the accumulated silt of the former river-bed will present itself as a ridge elevated above the surrounding ground; it is an *ose.*

"To sum up :

"*Osar are formed in running water.*

"*No running water could lift all this matter to the considerable altitudes where we often find it.*

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[1] Geol. of N. H. Vol. 3., pages 14-176.

[2] Swedish *ås* (pronounced *ose*), plur. *åsar*=*osar*—not "osars," as it is written by some authors.

"*The matter must therefore have been elevated by the ice, and must afterwards have moved down and amassed itself into osar in the above-stated manner.*"

In the second paper Dr. Holst gives an account of his visit to the west coast of Greenland in the summer of 1880. He went as far north as Sukkertoppen (lat. 65½° N., about), extending his rambles southward to Kipissako, southeast from Ivigtut[1] (lat. 61° N., about). He traveled mostly by water, in a so-called *Umiak* (boat rowed by women), but also made excursions by foot over the inland ice, ascending some of the highest mountain-peaks for the purpose of obtaining bird's-eye views over the ice and the various pinnacles—s. c. *nunataks*—which rise out of the inland ice.

After having given a general account of his travels, the author proceeds to discuss his observations under the following headings, viz.: the ground-rock, the inland ice, the kryokonite, the moraines, the upper drift deposits, the glacial clay, and the peat. We shall here reproduce the most important parts under the first five of these headings.

A. *The Ground-rock* in the district referred to is predominantly *grey gneiss.* A bed of *hälleflint-gneiss* was observed on the peninsula to the north of Tigssaluk. More variation was noticeable east and south of Ivigtut. A rather coarse-grained, well-developed *syenite* extends over the country a little to the east of Grönne Dal; a white, pretty *quartzite,* and also what may be called a *hälleflint-schist,* were seen near the southern ice-blink at Kornok, and a somewhat similar but very fine-grained *schistose hälleflint-gneiss* occurs at Kipissako.

No granite was seen north of Ivigtut; but a limited area of granitic rock extends to the north of Kipissako glacier.

In order to get some more definite knowledge of what rocks prevail in one locality, the author collected at random fifty specimens from the terminal moraine below the Ursuk-fjord glacier. Of these 50 specimens, 12 were found to be diorite; 9 grey gneiss; 7 granite (or granite-gneiss), some grey, some red; 6 grey hälleflinta;

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[1] Dr. Holst mentions, as a warning to other scientists who may go to Greenland with the intention of visiting the cryolite mines at Ivigtut, that admission to those mines is absolutely prohibited to all strangers not presenting a written permit from the head office at Copenhagen. He might have added, that such a permit is *never granted.*

4 hälleflint-schist; 3 red granite, of more than medium-coarse grain; 2 grey granite—otherwise like the last-named variety; 1 red hälleflint gneiss; 1 quartzite and 1 quartzite-sandstone; whilst the remaining 4 specimens were put down as undeterminable. In the same moraine were also noticed limestone, red fine-grained sandstone, coarser sandstone, and sandstone conglomerate, sometimes with nodules of jasper and diabas. The sandstones and quartzites are very compact, as is generally the case with older sandstones, and bear a complete resemblance to many Swedish sandstones generally regarded as *Cambrian.* C. Pingel (in 1843) expressed his opinion that they are *Permian;* and K. J. V. Steenstrup (in 1877) takes Pingel's side, and (in 1881) declares that there can be no reason for a different view as long as no petrifactions have been found in the sandstone. Yet there is no more reason to regard this rock as belonging to the Permian formation than to almost any other formation. Numerous dykes of diabase are met with in the southern portions of the district visited by Dr. Holst, all the way from Kipissako to Fredrikshaab. They are particularly abundant on the Tassiussak-fjord, and not less than twenty parallel dykes of greenstone were counted within a space of five hundred feet on the island Kikertarssuak, at the inlet to this fjord. East-southeast from Grönne Dal occurs a peculiar diabase breccia, and, close to it, dykes about a yard wide of a very fine-grained red rock, microscopically determined by Dr. A. E. Törnebohm[1] as a fine-grained *syenite.*

B. *The Interior Ice-covering.*—Previous explorers of the inland ice have made the observation that moraines are found on the surface of the ice only near land, while the inner expanse of the ice-sheet is earthless, except the occurrence of the so-called *kryokonite.* What else it carries along is hidden more or less deeply in the mass of the ice. Knowing this, Dr. Holst thought it more fruitful to study the ice near its borders than to undertake time-wasting excursions into the interior.

The inland ice expands in a continuous sheet from the mountains of the coast-lying land eastward beyond the horizon, only interrupted by the "nunataks" and the moraines. The former occur very sparingly, only the high peaks of the underlying mountains rising above the ice. Of the moraines may be especially mentioned the morain-osar, deposited on the ice parallel to its border, and in undulating or even horseshoe-curved lines, following at some distance the headlands jutting into the ice-sheet. These moraines Dr. Holst proposes to call *border-moraines* ("rand-moräner").

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[1] A. E. Törnebohm: Mikroskopisk undersökning af några bergartsprof från Grönland insamlade af Dr. N. O. Holst. Geol. Fören. Förh. Bd. 6, p. 692.

The ice within a hundred feet from its borders invariably presents a slope toward the border, though generally not so steep as to render the ascent at all difficult. Farther in the slope is much less marked, though there appears to exist a general rising toward the east, whilst the surface everywhere presents vast undulations.

The border of the ice appeared to have retreated quite recently in many places; in others it had evidently advanced. This seems to be the necessary effect of the varying amount of precipitation of snow or rain over the glacier-basin, causing the glacier itself to vary in volume. The snow fallen during the winter seems to remain much longer on the inland ice than on the land. Thus, at Atarngup, above the Tassiussak-fjord, on the 25th of June the inland ice was covered with snow. At the Fredrikshaab glacier, on the 4th of July, the snow had melted near land and around the "nunataks," but remained over a great part of the ice-sheet, although numerous bare spots were visible. Still later in the season—by the middle of September—Dr. Holst made an excursion over the inland ice to the north of the Kipissako glacier. All the snow from the last winter had disappeared, but some new snow, blended with rain, had fallen and frozen to a thin crust over the ice.

On the surface the inland ice either presented the appearance of a compact mass of coarse crystallinic texture, reminding of the grain of common rock-candy, or else it is honeycombed by the solar heat and shows intersecting systems of parallel plates, apparently the remnants of large ice-crystals, often several inches long, which have wasted away, only leaving the frame, as it were, on which they were built. These plates or tablets are highly mirroring, reflecting the solar rays in all directions, depending on the position of each individual crystal. The ice in the wild, mountainous regions of Southern Greenland is, as a matter of course, very much broken up by crevasses. Wherever the ice pushes forward and downward over an escarpment of the underlying ledge these crevasses, with great regularity, cross the direction or course of the glacier. Of most frequent occurrence, however, are the cracks which run at right angles to the borders of the inland ice.

Although the ice in the said mountainous district is everywhere crevasse-torn, it is not necessarily so in other localities. Where the underlying ground is level or only gently rolling, the moving ice is, no doubt, entirely free from cracks.

The local direction of motion must, of course, to a great extent conform to topographical conditions. Thus, in deep valleys glacial striæ may be found to run in all possible directions, always following the course of the valley. In order to find the general direction of the motion of the inland ice, one must study the striæ on the high plateaus. My observations in such localities indicate a direction from northeast or east-northeast.

The vastly broken aspect of a Greenland landscape cannot be explained as solely a product of the erosive force of moving glaciers. It is true that the material produced by this erosion is only to a small extent left on the land—where the soil is, indeed, very thin—whilst by far the greater part is deposited as silt in the sea. But if we suppose this silt to spread over the bottom of the sea for some miles from the coast and to have the thickness of several rods, still this cannot approximately account for the enormous excavations of the land. These must date farther back than the glacial period. The glaciers may, however, have plowed up and scooped out the loose sediments from earlier ages in the vast valleys.

On the inland ice occur *moraines* and *kryokonite* (glacial dust), besides patches of *vegetable matter*. The moraines are limited to the borders of the inland ice around the nunataks as well as along the coast-line. The kryokonite mostly accumulates between the moraines thus near to land, but is not altogether absent even from the high interior tracts of the ice-sheet. Vegetable matter occurs but sparingly on the ice. West of Kangarssuk, half a mile from land, were noticed some leaves of grasses, Betula, etc. They were not scattered, but heaped up in a pile—which seems to indicate that not wind, but water, had transported them to that position.

C. *The kryokonite* is extensively distributed over by far the greatest part of the inland ice, as well as over most of the local glaciers, though it may occasionally be hidden under snow or ice formed by the freezing of the thaw-water.[1] It varies, however, considerably in quantity. In many places, especially far inland, the kryokonite spreads only as a light shade over the ice, whilst near to land it exists in far greater abundance. At Fredrikshaab's ice-blink the border-ice was dirty from immixture of kryokonite and separated from the higher-located, cleaner ice by a sharply-defined line parallel to the foot of the inland ice, this line having an elevation of six hundred feet over the foot of the ice.

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[1] = Swedish smältvatten. The word, although not found in Webster, may serve to express the water formed at the surface of the ice by thawing.

The kryokonite has a dirty gray color, and upon superficial inspection appears like clay; but, on closer examination, it will be found to consist of very fine sand. Quite often it is formed in little balls as big as beans, which readily absorb heat from the sun, causing the underlying ice to melt, so as to produce the so-called "organ-pits." It may occasionally be washed down with the thaw-water from the higher places and then accumulate in patches. On the Arsuk glacier some such patches, about one square foot each in extent, were covered with kryokonite to a depth of three inches. It is not always easy to tell the difference between moraine-sand and kryokonite on the ice-rivers, where the moraine matter exists in every grade of fineness—from coarse gravel and sand to nearly impalpable dust, like the kryokonite. On the higher parts of the inland ice, where no moraines are found, this difference does not exist.

The following table shows the chemical composition of the kryokonite. No. 1 was a sample taken by Baron Nordenskiöld on lat. 68° 20′ N. Nos. 2–6 were taken by Dr. Holst. For comparison is added an analysis (A) of gneiss from Ostergothland, according to Dr. H. Santesson.

	1	2	3	4	5	6	A
Silicic acid	62.25	62.93	62.74	56.30	60.67	60.55	63.72
Titanic "	....	0.37	....	....	....	....	....
Alumina	14.93	12.24	14.18 (P[1])	16.45	15.63	14.97	15.74
Peroxide of iron	0.74	6.43	....	....	....	....	2.74
Protoxide "	4.64	....	3.90	4.10	6.35	6.28	4.31
Manganous oxide	0.07	0.32	0.92	0.54	1.10	0.14	1.29
Nickelous "	....	None	....	....	....	....	....
Cobaltous "	....	None	....	....	....	....	....
Talc	3.00	....	3.01	2.44	2.37	2.54	1.40
Lime	5.09	5.61	3.02	3.62	3.70	3 73	3.56
Soda	4.01	7.75	3.47	4.94	3.79	3.70	1.64
Potash	2.02	2.22	1.26	2.52	2.52	2.99	3.72
Phosphoric acid	0.11	None	....	....	....	....	....
Chlorine	0.06	....	....	....	....	....	....
Water	3.20[1]	2.23	4.25	9.69	4.78	4.89	1.00
	100.12	100.10		100.60	100.91	99.79	99.28

[1] Including hygroscopic water, 0.34.

In his "Account of an Expedition to Greenland, 1870," Nordenskiöld gives the above analysis No. 1, and, on the strength of it, pronounces the kryokonite "a trachytic sand of a composition (*e. g.*, the amount of sodium) which indicates that it does not derive its origin from the granite-bearing region of Greenland." He leaves the question open whether it is derived from the basalt region or from volcanoes supposed to exist in the interior of Greenland, or whether it is of meteoric nature. He regards it as a distinct species, for which he gives the chemical formula, and even states that its crystal form is probably monoclinic. By comparison with the analysis (A) of a Swedish gneiss, it becomes evident that his conclusions are invalid. Evidently the analyses point to the primitive rocks of Greenland as the origin of the kryokonite. Even the high percentage of soda has no great bearing on this question, as many Swedish gneisses[1] have a higher percentage of soda than the above No. 1.

Dr. Holst devoted special attention to the kryokonite in Greenland, and collected samples of it from ten different localities between lat. 61 N. and 65° 25′ N.[2]; and he came to the conclusion that this substance is nothing but the finest till separated by repeated washing.

The thaw-water from the surface of the inland ice penetrates through cracks into confluent gutters down in the moraines in the deeper parts of the ice, and, washing out the finest till, it continues its course until it connects with similar gutters, carrying water from higher-located tracts. Hydrostatic pressure will then force back water toward the lower tract. The suspended moraine matter will follow; but as soon as equilibrium is restored it will settle in pores and cracks of the ice. The water may but rarely reach the surface immediately. But when the moving glacier encounters an elevation of the ground, the lower portions of the glacier will be pressed up to a higher level. As the ice is melting away from the surface the enclosed matter will gradually appear at the top. Upon reaching the borders of the inland ice it will be carried away by the glacier-rivers and deposited in the sea. These rivers in Greenland are very turbulent, and the kryokonite, therefore, mingles with the clays and sands, which are whirled down by them into the sea. But if such inland ice were advancing over a plain, and the kryokonite were washed out from it by quietly-running water, it would, no doubt, get an independent geological significance.

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[1] According to Santesson's "Kemiska Bergarts analyser." Sveriges Geol. Undersökning.

[2] Nordenskiöld's samples were all taken from nearly the same locality, viz., about 68° N. lat.

This theory presupposes the existence of kryokonite, not only on the surface of the inland ice, but also in its deeper parts. That this is the actual case is plainly visible near the borders of the ice.

Microscopical analyses of the kryokonite were made in 1881 by A. von Lasaule, F. Zirkel, and E. Swedmark. All agree in the main: *The kryokonite contains nothing but the ordinary components of primitive rock.*

Professor Zirkel found Dr. Holst's samples to contain mainly the following minerals, viz., quartz, orthoclase, plagioclase, greenish and brownish mica,—which he supposes to be a magnesia mica,—and colorless potassium mica (this last mineral occurring but rarely) He also found some hornblende, garnet, magnetite, and (doubtfully) traces of titanite and epidote. In all cases the principal constituents were quartz, magnesia mica, and feldspar. The thinnest scales of mica pierce through the feldspar fragments, just as they do in the gneisses. Metallic iron was never identified in the samples. Professor Zirkel calls particular attention to the total absence of any augite, olivin, or glass. Both chemical and microscopical analyses agreeing, it may be regarded as a settled fact that the kryokonite has the same origin as the moraines. It is far more difficult to solve the question regarding the geological significance of the kryokonite. During his visit to Greenland, Dr. Holst was inclined to suppose that it nowhere forms independent deposits, but always occurs commingled with the clays and fine sands of the till, the kryokonite, as to its grain, being intermediate between the two. It is sand, but considerably less palpable than any ordinary kind of sand. However, since he had opportunity of studying the *loess* in Saxony, he came to the conclusion that *the loess is nothing but kryokonite.*

Considering the loess (kryokonite) as a product of repeated washing processes, in the manner above stated, it is easy to conceive why it has reached such remarkable extent and purity.

The State Geologist, E. Swedmark, having examined microscopically samples of loess collected at Ebendorff, near Magdeburg, and at Dresden, found them to consist of fine rock-powder, in which he identified fragments of *quartz* as the most prominent constituent, besides feldspar, plagioclase, green hornblende in considerable quantity, mica (mostly biotite), a trifling amount of magnetite, numerous dendritic or, sometimes, kidney-shaped grains of an *ochre*-like mineral, and fine particles of *clay* and *limestone*. Such a composition (says he) indicates certainly that this loess leads its origin substantially from disintegrated primitive rocks (gneiss or granite) and diorite.

The dust on the inland ice of Greenland offers a suitable soil for quite a number of small algæ. Professor V. B. Wittrock examined some of the samples of kryokonite, and the results of his investigations are embodied in his paper, "Om snöns och isens flora."[1]

(To be concluded.)

DESCRIPTION OF A NEW PRAIRIE MEADOW MOUSE (ARVICOLA AUSTERUS MINOR) FROM DAKOTA AND MINNESOTA.

BY DR. C. HART MERRIAM.

A LARGE series of meadow mice of the genus *Arvicola,* collected during the past two years in Minnesota and eastern Dakota, comprises but two species, which, in the field notes of the collector, Mr. Vernon Bailey, are designated respectively as "upland" and "lowland" meadow mice. The "upland" form is never found on the marshes, but the "lowland," which is most abundant in wet meadow lands and in the neighborhood of streams, sometimes occurs on the dry prairies in company with the other. Externally, some of these mice resemble one another so closely that sharp discrimination is necessary for their separation. A glance at their teeth, however, shows that they belong to different sub-genera. The "lowland" species has two external closed triangles on its last upper molar, a postero-internal loop or "spur" on its middle upper

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[1] A. E. Nordenskiöld: Studier och forskningar, föranledda af mina resor i höga norden. Stockholm, 1883, pages 63–124.